NASA TECHNICAL TRANSLATION NASA TT F-15,929

MICROBIOLOGICAL TRANSFORMATIONS OF PHOSPHOROUS IN VOLCANIC SOILS OF THE PURACE AREA

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Translation of "Transformaciones Microbiologicas del Fosforo en los Suelos Volcanicos del Purace", Acta Agronomica, Vol. 18, 1968, pp. 1 - 6.

(NASA-TT-F-15929) MICROBIOLOGICAL TRANSFORMATIONS OF PHOSPHOROUS IN VOLCANIC SOILS OF THE PURACE AREA (Scientific Translation Service) 11 p HC $4.00 CSCL 08M G3/13

N74-33860

Unclas 49302

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546 SEPTEMBER 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,929	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle MICROBIOLOGICAL TRANSFORMATIONS OF PHOSPHOROUS IN VOLCANIC SOILS OF THE PURACE AREA		5. Report Date September 1974
		6. Performing Organization Code
7. Author(s) M. Blasco L., N. Bohorquez A. and C. Llanos M.		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address SCITRAN Box 5456 Santa Barbara, CA 93108		11. Contract or Grant No. NASw-2483
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Transformaciones Microbiologicas del Fosforo en los Suelos Volcanicos del Purace", Acta Agronomica, Vol. 18, 1968, pp. 1 - 6.

16. Abstract

This study shows that immobilization is the predominant process in the volcanic soils of Purace in spite of a C:P organic ratio lower than 200. In these soils the C:P organic appears to be an unreliable index for predicting organic P mineralization.

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	9	

MICROBIOLOGICAL TRANSFORMATIONS OF PHOSPHOROUS IN VOLCANIC SOILS OF THE PURACE AREA

M. Blasco L., N. Bohorquez A. and C. Llanos M.*

1. Introduction /1**

The dynamic equilibrium of phosphorous in soils is a fairly complex phenomenon. While some forms such as ferric phosphates are very stable, other fractions -- such as organic phosphorous compounds -- are more readily converted into forms available to plants. There is a variety of microbiological transformations of phosphorous in soil, but within the cycle, mineralization and immobilization are probably the most important ones, since they affect the nutrition of vegetation more directly; some aspects thereof are discussed in this paper, as they relate to the volcanic soils of the Purace area.

2. Literature review

It is generally believed that the same factors that affect the mineralization and immobilization of nitrogen (pH, ventilation, organic matter type and content, etc.) analogously affect phosphorous (Alexander, [1]). If residues of young plants predominate in the organic matter, so will mineralization; if, instead, the material is more mature, there will be a tendency towards immo-

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** Numbers in the margin indicate pagination of original foreign text.

bilization because the substrate is easier to attack (Birch, [2]).

In concrete terms, it is being accepted that for C: organic P ratios of less than 200:1, mineralization will occur, while immobilization will be the predominating effect at ratios of 300:1 or higher (Alexander, [1], Black and Goring, [3]). Recent research by Enwezor [6], however, has shown that the ratio of mineralization/immobilization depends more on the total quantity of organic phosphorous present than on the C: organic P ratio.

Substrate qualities must also be taken into account. The two main sources of organic phosphorous in soil are nucleic acids and phytin. If the nucleic /2
acids abound, a rapid dephosphorilation will take place; phytin, instead, is the phosphorous compound of slowest mineralization (Fabry, [7]).

3. Materials and methods

The samples were collected in the Purace volcanic region. This volcano is part of the Central Range of the Andes, in the province of Cauca; its elevation is 4,756 m above sea level. The soils were located along the Popayan - El Vinagre highway (sulfur mining), between 3,000 and 4,000 m; the latter altitude is slightly above the mining camp. The average temperature at El Vinagre is 10°C (there are no rainy days). Some of the characteristics of the soils investigated are shown in Table 1.

Incubation of each sample was performed as follows: 10 g soil (air dried, 2 mm mesh) were placed in a test tube and water was added to restore its previously determined humidity. A container with barium peroxide (moistened with a saturated barium hydroxide solution) was placed in each tube to absorb CO_2 and generate O_2 (Cornfield, [5]). The tubes were sealed and incubated for 4 and 8 weeks. Duplicates were processed and, where necessary, the containers were replaced.

Before and after the appropriate incubation periods, available phosphorous

TABLE 1

Soils	m above sea level	Depth pro-file, cm	pH	C.C.C. meq/100g	org. C ppm	org. P ppm	C/P org.
Volcano a	4,000	0 - 12	3.9	27.4	58,816	1,700	34.6
b		12 - 200	4.3	44.8	80,500	1,976	40.7
Vinagre a	3,700	0 - 50	4.5	49.6	99,284	1,810	54.8
b		50 - 200	4.6	40.7	54,765	2,224	24.6
Purace a	3,400	0 - 80	4.7	46.3	81,222	2,712	29.9
b		80 - 150	5.4	25.5	37,674	997	37.8
Coconucos a	3,000	0 - 25	4.9	33.4	67,612	1,733	39.0
b		25 - 60	5.3	21.0	22,403	427	52.4

was extracted by shaking the samples (1 min) with 20 ml of 10% sodium acetate buffered with acetic acid (Morgan, [12]); organic phosphorous was determined by the Saunders and Williams [13] combustion method. Extinction was measured on adequate aliquots with a Beckman C colorimeter, after development of the blue stannous chloride-molybdophosphoric acid coloration.

The pH was determined on the paste, the cationic exchange capacity by means /3
of ammonium acetate and organic carbon according to the Walkley-Black method (Jackson, [8]). The clay content was established by the hydrometer technique (Bouyoucos, [4]).

Bacteria and fungi in the soil were determined by Martin's plate dilution method [11].

4. Results and Discussion

The phosphorous mineralization and immobilization results obtained are shown in Table II and the changes in bacteria and fungi population in Table III.

With the exceptions of the Purace-a soil and the Coconucos-b subsoil (over

TABLE II. MICROBIOLOGICAL TRANSFORMATIONS OF PHOSPHOROUS AFTER INCUBATION FOR 4 AND 8 WEEKS (30°C, pF 2.7). RESULTS AS P, IN ppm

Soil	Without incubation P available	Incubated soil: Mineralized/immobilized P 4 weeks	8 weeks
Volcano a	3.9	- 2.0	- 3.7
b	6.1	- 2.2	- 4.9
Vinagre a	8.2	- 1.6	- 1.5
b	4.0	- 1.3	- 2.1
Purace a	10.2	0.8	1.4
b	2.9	- 2.4	- 2.4
Coconucos a	5.7	- 3.3	- 2.6
b	2.3	0.5	- 1.9

only 4 weeks for the latter samples), this study shows a clear advantage for immobilization over mineralization. According to these results -- and in agreement with Enwezor [6] -- the direct C: organic P ratio is not a reliable index to predict which of these phenomena will predominate. At least in regard to volcanic soils these data show that mineralization or immobilization occur independently of the ratio mentioned.

By comparison of the bacteria and fungi population before and after 8 weeks of incubation (Table III) it can be seen that there is a decisive increase in bacteria in all samples, while fungi -- with the exceptions of the Volcano-a and b and the Coconucos-b samples -- decrease in number. With the possible exception of other types of undetermined microorganisms, bacteria seem to be more effective than fungi in the assimilation of phosphorous and its accumulation in unavailable forms (protoplasmatic substances: nucleic acids, phospholipids, etc.) for the periods of incubation selected.

Studying volcanic soils, Kosaka and Abe [10] established that 80% of the phosphorous was organic, and mainly phytin and its derivatives. It is very likely that the case of our soils is similar (although the chemical nature of the phosphorylated compounds was not determined here), which would help in explaining to a large degree the lack of mineralization.

TABLE III. BACTERIA AND FUNGI POPULATION IN THE ORIGINAL SOILS (WITHOUT INCUBATION) AND AFTER INCUBATION (30°C, pF 2.7) FOR A PERIOD OF 8 WEEKS /4

Soils	Without incubation		8 week incubation	
	Bacteria	Fungi	Bacteria	Fungi
Volcano a	4,132	350,333	262,920	2,803,333
b	1,500	151,000	48,000	4,086,666
Vinagre a	2,500	1,060,000	746,500	537,500
b	0	157,975	407,500	113,666
Purace a	1,350	330,500	261,666	68,200
b	400	191,796	352,750	94,300
Coconucos a	32,400	2,766,750	1,038,580	33,132
b	4,000	7,000	313,000	11,900

On the other hand and taking into account that the mineralization mechanisms are fairly similar for nitrogen and phosphorous (Alexander, [1]), the low pH of the samples investigated does not favor microbiological processes.

Finally, it should be added that in the case of acid soils it is possible that the actually liberated phosphorous may not extract as an accessible fraction because -- as Jahn-Deesbach [9] has pointed out -- it is fixed by iron, aluminum or other soil constituents. Besides, the processes by means of which phosphorous is fixed in acid soils are well known.

From a study of the microbiological populations it appears that an increase in the environment temperature from approximately 10°C to 30°C, and an adjustment of the humidity to pF 2.7 favors bacterial growth and tends to restrict fungus population, with the exception of the volcano samples. With relatively optimum conditions for these two factors, bacteria were probably better able to utiliza the elements (mainly calcium) available from decomposing organic matter.

5. Summary

This study shows that immobilization is the predominant process in the volcanic soils of Purace in spite of a C: organic P ratio lower than 200. The C: organic P ratio in these soil samples appears to be an unreliable index in predicting organic P mineralization.

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Translated for National Aeronautics and Space Administration under contract No. NASw 2483, by SCITRAN, P. O. Box 5456, Santa Barbara, California, 93108.